ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Study on Effect of Joints in Segmental Concrete Bridges

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Abstract: **-- The segment of segment joints is the locations of primary concern in the analysis and design of segmental concrete bridges. Joints are responsible for the transfer of bending moments and shear forces developed in one segment to the other. Hence in the majority of the cases, the capacity of the joints becomes the governing factor than the capacity of the segments. The capacity of joints depends upon the level of fixity between the segments. It is practically impossible to provide a fully fixed joint between the segments. Hence in this paper, the efficiency of joints with varying levels of fixity has been studied and is then compared with a geometrically similar continuous box girder bridge. It has been observed that efficiency of joints directly depends upon the level of fixity between the segments.**

***Index Terms*: - Bending moment, Box girder, Joints, Segmental concrete bridge.**

I. INTRODUCTION

Segmental concrete bridges are those type of bridges in which primarily load carrying members are composed of individual members, known as 'segments', which are post-tensioned together to make one complete span. Segmental construction technique is economical for large spans (greater than 30m) and is widely used in construction sites where access is limited. It enables versatile and fast construction of bridges. This technique can be incorporated into a variety of bridge decks such as box girders, cable stayed bridges, arch bridges etc. An example of a post tensioned precast segmental bridge is shown in the Fig.1.

Fig.1 Post-tensioned precast segmental bridge (source-http://sunengineering.cn)

Segment to segment joints are the locations of primary concern in segmental bridge analysis since they cause discontinuity in the bridge. Knowledge on the behaviour of joints is essential to predict the response of the bridge throughout its life span. Behaviour of joints largely depends upon the level of fixity between the segments. Therefore, in this paper, a study on effect of joints with varying levels of fixity in a segmental concrete box girder bridge comparing it to a geometrically similar continuous box girder bridge has been done and is presented.

II. JOINTS BETWEEN SEGMENTS

Joints can be either dry or epoxied. The shear strength of epoxy joints is higher than that of dry joints. But the failure of epoxy joints was found to be more brittle than dry joints [1]. During the earlier stages of this construction technique, single keys were provided in the web section which were reinforced in the key area. However, current practise is to provide multiple keys distributed throughout the height of web and flanges and are unreinforced in the key area. This facility provides better interlocking performance [4]. Joints are responsible for the transfer of developed moments and shear forces from one segment to the other and also ensure the durability of the structure by protecting the tendons against corrosion. If joints are inadequate, moments and shear forces can't be transferred properly, which in turn develops excessive stresses on one particular segment. Generally segments are not designed for such high stresses and this leads to excessive deformation and failure of that segment. Thus segment joints

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are locations of potential weakness in the entire bridge and excess care has to be taken during analysis and design in such locations.

III. METHODOLOGY

Efficiency of joints primarily depends upon their fixity. If joints are very stiff they behave more or less like a fixed joint and transfer the moments and shear forces efficiently. But in practise, it is very difficult to achieve a fully fixed joints. As the level of fixity decreases, efficiency to transfer the forces and moments also decreases. In actual segmental bridges, there will be only partial fixity between segments. In addition, the effective width available for the dispersion of load is less in the case of segmental bridges compared to continuous girder bridges which increases the load on the segments. Therefore moments and shear forces developed will be more compared to a geometrically similar continuous bridge.

A continuous and segmental box girder bridge of span 10m is considered for the study. The cross-section of the same is as shown in the Fig.2.

Single axle 70R load is taken as the live load for the analysis. Segmental bridge is modelled and analysed for different levels of fixity between joints and the result is compared with that of the continuous box girder bridge

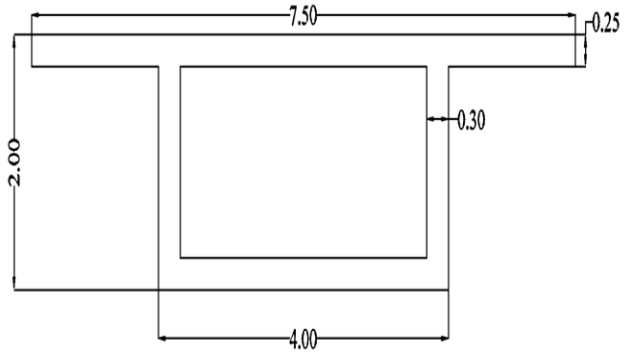
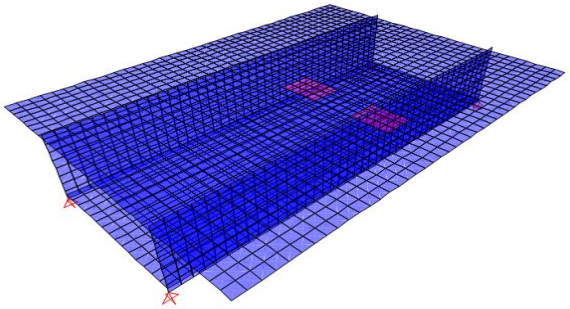


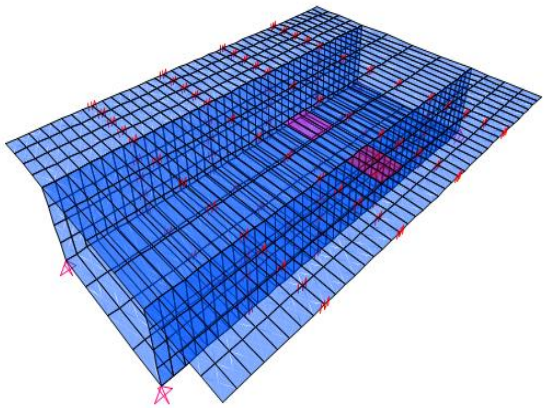
Fig.2 Cross-section of box-girder (All dimensions in m)

IV. MODELLING

Continuous box girder and segmental box girder was modelled in SAP 2000 as shown in the Fig.3 [2]. Thick shell element was taken for the analysis. Span of the bridge was taken 10m for both the cases. Segmental bridge is divided into five segments each of 2m length. Segment to segment joint gap is taken as 5mm. Gap element with 6 dof was used to model the segment joint. Five different cases with varying stiffness of the gap element (k) was considered for the analysis.



(a)



(b)

Fig.3 Mathematical model and loading of (a) Continuous box girder, (b) Segmental box girder

V. RESULTS AND OBSERVATIONS

The values of bending moments for different cases considered are shown in the Table 1. Variation of bending moment with respect to stiffness of the gap element is shown in the Fig.4.

Table 1 Bending moment values

Type of bridge`		Bending Moment (kNm/m)
Continuous box girder		18.93
Segmental box girder	K=100kN/m	49.78
	K= 1000kN/m	46.49
	K= 10000kN/m	33.75
	K= 100000kN/m	21.18
	K= 1000000kN/m	19.23

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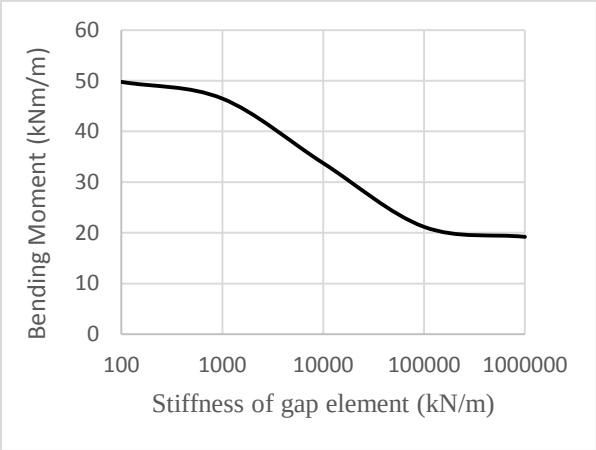

Fig. 4 Variation of bending moment w.r to stiffness for segmental bridge

Observations from the study can be summarized as follows:
Capacity of the entire bridge depends upon the capacity of the joints.
Efficiency of joint directly depends upon the level of fixity between joints.
As the stiffness of the gap element increases, bending moment developed decreases.
Segmental bridge behaves more or less similar to continuous bridge when the stiffness of the gap element is very high.

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